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# A CRITICAL LITERATURE REVIEW ON UTILISATION OF USED FOUNDRYSAND IN INTERLOCKING PAVER BLOCKS

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## ABSTRACT

The presently paver block is used in outdoor versatility application and also it is used in street road and other construction places. Paver block has low cost maintenance and easily replace with a newer one at the time of breakage. Foundries for the metal-casting industry generate by- products such as used foundry sand. Applications of foundry sand, which is technically, sound, environmentally safe for sustainable development. Use of foundry sand in various engineering applications can solve the problem of disposing of foundry sand and other purposes. Foundry Sand can be used as a partial replacement of cement in supplementary addition to achieve different properties of concrete. For improving economic feasibility and other parameter of paver block this research study is necessary. This research study presents the information about the development of interlocking paver block at the lowest cost in comparison of ordinary concrete paver block.

**KEYWORDS:** Industrial Waste, Used Foundry Sand, Interlocking Paver Block, Cost

## INTRODUCTION

### About Foundry Sand

Foundry sand is high-quality uniform silica sand that is used to make moulds and cores for ferrous and nonferrous metal castings. Foundry sand consists primarily of silica sand, coated with a thin film of burnt carbon, residue and dust. Foundry Sand can be used as a partial replacement of cement or as a partial replacement of fine aggregates or total replacement of fine aggregate and as a supplementary addition to achieve different properties of concrete Foundry sand can be used in concrete to improve its strength and other durability factors. The foundry sand is a mixture of several elements that combine features of giving perfect workability of the mixture that comprises the molding box. Consequently, 9 to 10 million tons of sand is discarded each year. Over the last 20 years more than 30.000.000 cubic meters of waste were discarded in sanitary landfills, and currently the reuse of it is being encouraged.

**Table 1: Country V/S Foundry Production: Scenareo of World**

| Country | 2009 | | 2010 | | 2011 | |
|---|---|---|---|---|---|---|
| | MT | R | MT | R | MT | R |
| China | 35.3 | 1 | 39.6 | 1 | 41.26 | 1 |
| Us | 7.40 | 2 | 8.24 | 3 | 10.01 | 2 |
| Japan | 4.40 | 4 | 4.76 | 5 | 5.47 | 4 |
| India | 7.40 | 3 | 9.05 | 2 | 9.99 | 3 |
| Germany | 3.90 | 5 | 4.79 | 4 | 5.46 | 5 |
| Brazil | 2.30 | 7 | 3.24 | 7 | 3.34 | 7 |
| Italy | 1.67 | 9 | 1.97 | 9 | 2.21 | 9 |
| France | 1.74 | 10 | 1.96 | 10 | 2.04 | 10 |
| Korea | 2.10 | 8 | 2.23 | 8 | 2.34 | 8 |
| Russia | 4.20 | 6 | 4.20 | 6 | 4.3 | 6 |

**M.T. =** Million tons, R= Rank

**Source:** Census of World Casting Production

**Table 2: Country V/S Foundry Production: Scenareo of World**

| Year | Sanitary Casting | Industrial Casting | Total |
|---|---|---|---|
| **2001-02** | 524.00 | 880.00 | 1,404.00 |
| **2002-03** | 609.00 | 1,038.00 | 1,647.00 |
| **2003-04** | 867.00 | 1,058.001 | 1,925.00 |
| **2004-05** | 1,242.00 | 1,383.00 | 2,652.00 |
| **2005-06** | 1,530.00 | 1,467.00 | 2,997.00 |
| **Predicted 2011-12** | 2,536.00 | 2,054.00 | 4,590.00 |

**Source:** Census of World Casting Production

## FOUNDRY SAND CLUSTER IN INDIA


**Source:**Institute of Indian Foundry Man

**Figure 1: Foundry Cluster**

## AREA UTILIZATION

Foundry sand can be suitable for a variety of beneficial reuses. Terminology for defining uses varies across states. For the purposes of this study, common uses of sand in consultation with industry experts. The following are the uses of foundry sand approved in one or more states:

### Structural Fill

Foundry sand can be used as support for structures such as road- ways, parking lots, buildings, and pieces of equipment. "Encapsulated" structural fill may involve the use of a liner, cap, or cover, generally made of a clay material, which prevents water from percolating through the foundry sand and minimizes the potential for leaching.

### Manufacturing another Product

Foundry sand is useful as a raw material in manufacturing other prod- ucts, such as controlled, low-strength material (CLSM or flowable fill), asphalt, cement, concrete, grout, lightweight aggregate, concrete block, bricks, roofing materials, plastics, paint, glass, ceramics, and rockwool.

### Specific Examples of These Uses Include

### Flowable Fill

Flowable fill is a liquid like material that self compacts and is used as a substitute for conventional soil backfill. The product is easily transported and can be readily re-excavated. The typical mixture contains sand, fly ash, Portland cement, and water. Foundry sand can readily be substituted for virgin sand in flowable fill mixtures.

### Cement and Concrete

Sand is acomponent of Portland cement and concrete. Portland cement requires sand with a silica content of at least 80 percent, which most foundry sands meet. It also requires certain minerals such as iron and aluminium oxides, which are found in many foundry sands. Cement and additional sand or gravel are components of concrete, allowing further reuse of foundry sand.

### Soil Manufacturing and Amendment

Commercial soil blending operations can use foundry sand to produce horticultural soils, topsoil, potting soil, and turf mixes. These soil products are typically mixtures of sand or gravel with peat, fertilizers, and/or topsoil. Foundry sand can also improve the performance of agricultural soils, and can be used as a composting ingredient.

### Landfill Uses

Foundry sand can be used as a cover for the working face of an active landfill, for road construction within the active cell, or as a substitute for virgin aggregate in the construction of drainage layers for landfill collection systems.

### Pipe Bedding and Backfill

Foundry sand can serve as backfill for trenches created by the installation of storm and sanitary sewer lines.

## TYPES OF FOUNDRY SAND

Basically 6 types offoundry sands are wellknown as the by-products from Metal casting industries.


**Source:** http://www.themetalcasting.com/casting-sand.html

**Figure 2: Types of Foundry Sands**

But most probably the basic two types of foundry sands used in construction industries (Metal casting) practical problems as a problem solving techniques as below:

Both types of sands are suitable for beneficial use but they have different physical and environmental characteristics

- Clay bonded systems (Green sand) and
- Chemical- bonded systems.

**Green sand** moulds are used to produce about 90% of casting volume in the U.S. Green sand is composed of naturally occurring materials which are blended together; high quality silica sand (85-95%), bentonite clay (4-10%) as a binder, a carbonaceous additive (2-10%) to improve the casting surface finish and water (2- 5%). Green sand is the most

commonly used recycled foundry sand for beneficial reuse. It is black in colour, due to carbon content, has a clay content that results in a percent- age of material that passes a 200 sieve and adheres together due to clay and water.

**Source:** http://www.foundrychem.com/green_sand_partings.aspx

**Figure 3**

**Chemically bonded sands** are used both in the core making where high strengths are necessary to withstand the heat of molten metal, and in mould making. Most chemical binder systems consist of an organic binder that is activated by a catalyst although some systems use inorganic binders. Chemically bonded sands are generally lighter in colour and in texture than clay bonded sands.

**Source:** Foundry Industry, GIDC, Vallabh Vidyanagar

**Figure 4: Chemically Bonded Sands**

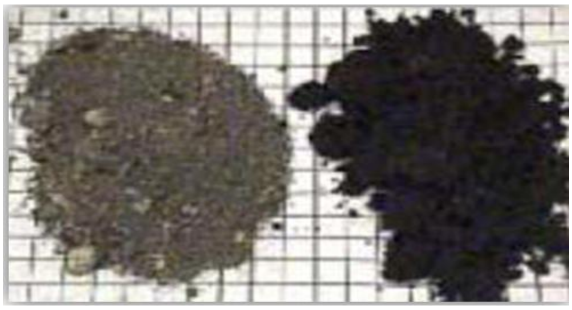
## PHYSICAL CHARACTERISTICS OF FOUNDRY SAND

Foundry sand is typically sub angular to round in shape. After being used in the foundry process, a significant number of sand agglomerates form. When these are broken down, the shape of individual sand grains is apparent.

**Source:** R. Siddique, Waste Materials and By-Products in Concrete, Springer-2008

**Figure 5: Unprocessed Foundry Sand**

Green sands are typically black, or grey, not green chemically bonded sand is typically a medium tan or off-white colour Figures 5 & 6 shows the unprocessed foundry sand and green sand respectively



**Source:** R. Siddique, Waste Materials and By-Products in Concrete, Springer-20

**Figure 6: Green Sands from a Grey Iron Industry**

## TYPICAL PHYSICAL PROPERTIES OF SPENT GREEN FOUNDRY SAND

**Table 3: Typical Physical Properties of Spent Green Foundry Sand**

[American Foundry man's Society, 1991]

| Property | Results | Test Method |
|---|---|---|
| Specific Gravity | 2.39-2.55 | Astm D854 |
| Bulk Relative Density, kg/m$^3$ (lb/ft$^3$) | 2589(160) | Astmc48 / Aastho T84 |
| Absorption, % | 0.45 | Astm C128 |
| Moisture content, % | 0.1-10.1 | Astm D2216 |
| Clay Lumps and Friable Particles | 1-44 | Astm C142/ Aastho T112 |
| Coefficient of Permeability (cm/Sec) | 10-3-10-6 | Aastho T215/ Astm D2434 |
| Plastic Limit/Plastic Index | Non plastic | Aastho T90/ Astm D4318 |

**Source:** R. Siddique, Waste Materials and By-Products in Concrete, Springer-2008

## CHEMICAL COMPOSITION OF FOUNDRY SAND

**Table 4: Chemical Composition of Foundry Sand**

| Constituents | Value (%) |
|---|---|
| $SiO_2$ | 87.91 |
| $Al_2O_3$ | 4.70 |
| $Fe_2O_3$ | 0.94 |
| CaO | 0.14 |
| MgO | 0.30 |
| $SO_3$ | 0.09 |
| $Na_2O_3$ | 0.19 |
| $K_2O$ | 0.25 |
| $TiO_2$ | 0.15 |
| SrO | 0.03 |
| LOI | 5.15 |

**Source:** R. Siddique, Waste Materials and By-Products in Concrete, Springer-2008

## ADVANTAGES OF FOUNDRY SAND

- In Embankments
- In Barrier layers construction
- In Flowable fills
- In Road way construction
- As Soil reinforcement

- In Hot mix asphalt
- In Portland cement concrete

**Other Engineering Application**

- Portland cement manufacturing
- Mortars
- Agriculture /soil amendments
- Verification of hazardous materials
- Smelting
- Rockwool manufacturing
- Fiberglass manufacturing
- Landfill cover or hydraulic barriers

## LIMITATION

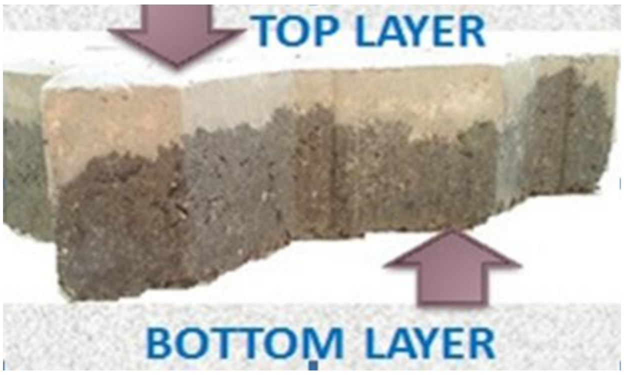
- Foundry sand is black. In some concretes, this may cause the finished concrete to have a grayish/black tint, which may not be desirable.
- A 15% fine aggregate replacement with foundry sand produces a minimal color change. Also, the foundry must be able to meet the quantity requirements of the precast manufacturer.
- Foundry sand reduced workability of concrete.

## ABOUT PAVER BLOCK

Interlocking Pavers are the modern day solution for low cost outdoor application. Paver block is solid, unreinforced pre-cast cement concrete paving units used in the surface course of pavement.

In paver block different types of material are used.

- **In top layer** : Cement, Dolomite powder and Pigment and
- **In bottom layer**: Cement, Fine aggregate, Semi grit, Quarry dust.

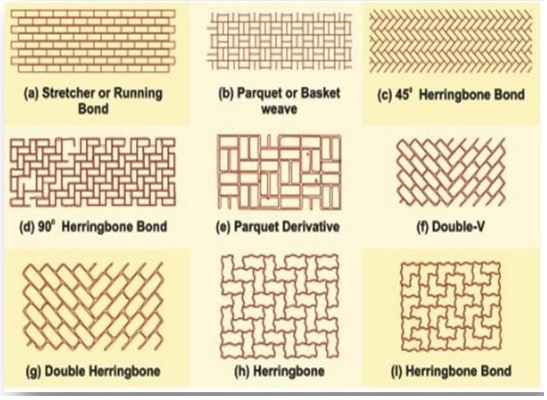



**Source:**Jay Maharaj Tiles, Kanjari

**Figure 7: Layer Distribution of Paver Block**

They are high strength concrete precast elements in various shapes, sizes &colors to suit the imagination of landscape architects & nature's essence. Interlocking pavers are manufactured concrete product that is individually placed in a variety of patterns and shapes as per the requirement.

## VARIOUS LAYING PATTERN




**Source:** http://www.google.co.in/images

**Figure 8: Various Laying Pattern of Paver Block**

## ADVANTAGES

- They are high strength concrete mouldings in various shapes, sizes and colours to suit the imagination of landscape architects & nature's essence.
- Construction of ICBP is labour intensive and requires less sophisticated equipment.
- They do not absorb water and can be placed so that excess water is taken away from the garden and covered area rather than over-saturating it.
- Use of coloured blocks facilitates permanent traffic markings
- ICBP is resistant to punching loads and horizontal shear forces caused by the manoeuvring of heavy vehicles
- Low maintenance cost and a high salvage value ensure low life cycle cost.
- Maintenance of ICBP is easy and simple and it is not affected by fuel and oil spillage.

## DIS-ADVANTAGES

- Quality control of blocks of the factory premises is a prerequisite for Durable Interlocking Concrete Paver Blocks "ICPB"
- High quality and gradation of coarse bedding sand and joint filling material are essential for good performance.
- Any deviations of the base course profile will be reflected on the "ICBP" surface. Hence extra care needs to be taken to fix the same.

**Table 5: Area of Application**

| Roads | Commercial Projects | Industriala Areas | Specialised Applications |
|---|---|---|---|
| Main roads | Shopping centres and malls | Factories and warehouses | Cladding vertical surfaces |

**Table 5: Contd.,**

| | | | |
|---|---|---|---|
| Urban renewal | Parks and recreation centres | Military applications | Stormwater channels |
| Toll plazas | Service stations | Mines | Townhouses and cluster homes |
| Steep slopes | Golf courses and country clubs | Airports and harbours | Roof decks |
| Pavements (sidewalks) | Office parks | Wastewater reduction works | Embankment protection under freeways |
| Intersections | Zoos | Container depots | Pool surrounds |

## CONCLUSIONS

The application of a used foundry sand as a replacement with cement is feasible for strength in interlocking paver blocks. Used foundry sand can be used to prepared low cost temporary structure. It can be used in non-structural elements with the low range compressive strength where strength is not required. Use of foundry sand in concrete can save the ferrous and non-ferrous metal industry's disposal, cost and produce a ‘greener’ concrete for construction. Environmental effects of wastes and disposal problems of waste can be reduced through this research. Innovative Construction Material is formed through this research. Uses of foundry sand in concrete can save the disposal costs of casting industry and produce a ‘greener’ concrete for construction. So by this usage of replacement of used foundry sand as a partial replacement of cement in interlocking paver blocks is more economical rather than ordinary interlocking paver blocks. An innovative supplementary construction Material is formed through this research study.

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